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TARGETING AND WEAPONS REQUIREMENTS IN CLOSE AIR SUPPORT STRIKE OPERATIONS

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INTRODUCTION

This paper presents a Naval Weapons Center study on close air support (CAS) targeting requirements and systems. The paper gives an overview of U.S. Marine Corps CAS and identifies problems in specific areas of the CAS mission, including threat, communications, timing, target marking, and target acquisition. The study also analyzes CAS targeting requirements and formulates guidelines for improvement of CAS targeting capabilities.

MISSION DEFINITION

Close Air Support

CAS is defined as air action against hostile targets that are in the proximity of friendly forces. Detailed integration of each air mission with the fire and movement of the friendly forces is required.

Close-in Fire Support

The support furnished to ground troops by Marine Corps attack helicopters is called close-in fire support (CIFS). The same coordination with ground and air forces is required. The CIFS mission is different from CAS in force structure and ordnance employed, but is included in this study since it is also air support provided to ground troops.

Target Acquisition

Target acquisition is the term used to indicate the process of locating the target once the general target area has been entered. The target acquisition process usually begins with some type of search; includes detection, recognition, or identification; and ends when the weapon has been released, fired, or locked onto the target. The use of "acquire" in this report denotes whatever task (or tasks) is appropriate in the context of the discussion.

The unique functions in CAS of air-to-ground communications and targeting marking can also be included as part of the target acquisition process. A target marker (e.g., smoke, panels, or a laser designator spot) could also be thought of as the first of two targets in the search process, with the target itself the final objective.

STUDY METHOD

This study was carried out in three phases:

1) Review of CAS studies, handbooks, operational reports and instructor materials, with weighting given to analysis and experience over the last eight years.

2) Interviews with U.S. Marine Corps (USMC) aviators.

3) Synthesis of information gained from the literature and from interviews as the basis for identification of the problems, their causes, and possible improvements in CAS targeting.

The study is qualitative in nature; assumptions and important factors in CAS target acquisition are simply stated with quantitative supporting data. These statements are generally agreed to in the operational and technical communities. Conclusions as to target acquisition requirements can be derived from the statements, and these sets of requirements can form the "shopping list" for choices of targeting device development.

SCOPE

Most of the target acquisition functions required of Marines in combat are given in Table 1, where the components (or "players") are also listed. The table shows the wide range of operations that include some form of target acquisition. Items were reduced in number to those predominant in the air-to-ground attack, CAS mission (Table 2). Table 3 further restricts the scope of Table 2 to items most appropriate to targeting per se.

TABLE 1. Complete Classification of Target Acquisition Spectrum.

I. Ground-to-ground

a. Components:[a]

1. Ground troops (e.g., infantryman, forward observer)
2. Vehicle crews (e.g., Dragon gunner)
3. Artillery crews

b. Functions:[a]

1. Acquire/track enemy before firing
2. Direct fire on enemy
3. Designate enemy (e.g., with a laser device or smoke marker)
4. Report enemy location

II. Ground-to-air

a. Components:

1. Troops
2. Antiair weapon units (e.g., Hawk unit)

b. Functions:

1. Acquire friendly cargo helicopters (helos)
2. Acquire friendly forward air controllers (airborne) (FAC(A))
3. Acquire friendly attack aircraft
4. Acquire enemy air (helo and jet)

III. Air-to-air

a. Components:

1. Helos
2. FAC(A)/tactical air coordinator (airborne) (TAC(A))
3. Fighter aircraft
4. Attack aircraft

b. Functions:

1. Acquire enemy aircraft
2. Acquire own aircraft

IV. Air-to-ground

a. Components:

1. Cargo helos
2. Troop helos
3. Attack helos
4. FAC(A)
5. Fighter/attack jets

b. Functions:

1. Acquire own forces
2. Acquire landmarks (e.g., control points, identification points)
3. Acquire target marker
4. Acquire target
5. Acquire landing site

[a] Numbers assigned to components and functions are not necessarily correlated.

TABLE 2. CAS Target Acquisition Functions.

Other functions in the CAS operation are not included here (e.g., acquiring enemy aircraft).

I. Ground-to-ground

- a. Components: Troops
- b. Functions:
  1. Direct fire
  2. Designate target
  3. Report target location

II. Ground-to-air

- a. Components: Troops
- b. Functions:
  1. Acquire own FAC(A)
  2. Acquire own attacker

III. Air-to-air

- a. Components:
  1. Helos
  2. FAC(A)
  3. Fighter/attack jets
- b. Function: Acquire other friendly aircraft

IV. Air-to-ground

- a. Components:
  1. Attack helos
  2. Fighter/attack jets
  3. FAC(A)
  4. Ground support (FAC, air support radar team)
- b. Functions:
  1. Acquire own forces
  2. Acquire target marker (e.g., smoke, laser spot, radar beacon)
  3. Acquire landmarks
  4. Acquire target

TABLE 3. Study Priorities in CAS Targeting.

I. Air-to-ground

- a. Components:
  1. Fighter/attack jets
  2. Attack helos
  3. Observer aircraft
- b. Functions:
  1. Acquire target
  2. Acquire target marker
  3. Designate target (from air or ground)

II. Ground-to-ground

- a. Components: Troops
- b. Function: Designate targets

Two other important functions are closely related to an attack aircraft pilot finding the target: communications and marking the target (Table 4). These two areas are treated explicitly in this study since they have been key components in the CAS target acquisition process and are not found at all in other types of air-to-ground target acquisition.

TABLE 4. Additional Functions in CAS Targeting.

I. Communication

a. Components:[a]

1. Tactical Air Command Center (TACC)
2. Direct Air Support Center (DASC)
3. Fire Support Coordination Center (FSCC)
4. TAC(A)
5. FAC(A)
6. Ground support (FAC, air support radar team)
7. Attack aircraft

b. Functions:[a]

1. Request air strike
2. Direct aircraft to target area.
3. Pass target and strike information
4. Mark target
5. Clear aircraft for strike, or abort strike
6. Coordinate timing

II. Mark/designate target

a. Components:

1. Troops (FAC, artillery crew)
2. FAC(A)
3. Fighter/attack aircraft

b. Functions:

1. Locate targets
2. Launch marking munition
3. Track and designate target
4. Estimate or measure range and bearing to target
5. Describe target location to FAC(A) or attack aircraft
6. Time target marker properly

[a] Numbers assigned to components and functions are not necessarily correlated.

THE CAS MISSION

This section gives a broad overview of the Marine Air CAS and CIFS missions. A number of studies have been conducted, and handbooks and trial reports are available that provide a great amount of detailed information on threats, weapons, targets, and their associated tactics. Since the information is available, only its essence need be repeated here.

Aircraft

The principal attack aircraft involved in CAS will be the AV-8B, A-6E, and F/A-18. (The A-4M and F-4N/S will be used in the reserve forces.) The OV-10 is the aircraft in use by FAC(A) in the Marine observation squadrons. The AH-1J/T is the attack helicopter that provides CIFS. Two of the attack aircraft are single-place types, so the pilot will be heavily task-loaded in the CAS environment. The A-6E, F-4S/N, and AH-1J/T have two crewmen, so there will be sharing of the work.

Threats

The major threats will be mobile weapons that include the ZSU-23-4, small arms and automatic weapons, and several varieties of surface-to-air missiles (SAMs). Air threats from enemy fighters are also a possibility, and Hind helicopters could be a threat in some scenarios. The threats will use radar as well as electro-optical and infrared (EO/IR) sensors to locate and track the Marine aircraft. The specific location of the threats may not be known ahead of time, because of their mobility.

Targets

Most of the targets in the majority of the CAS scenarios will also be mobile - tanks, armored personnel carriers (APCs), and vehicle-mounted artillery. Targeting the threats themselves (ZSU-23-4) would also be effective. If the Marine ground forces are attacking, such things as fortifications (bunkers) could also become targets.

The vehicular targets are considered "point" targets (as opposed to area targets), whose location can change because of their mobility. This type of target is not easy to see unless it is raising dust in a dry environment, or is marked or designated by a FAC or FAC(A).

Environment

The Marines could encounter a broad range of environments; e.g., flat, open country with little vegetation; hilly country with little vegetation or covered with trees; open farmland; or built-up coastal regions, including urban areas. Operations must be performed day and night in all seasons. Limited visibility and low ceilings make air operations difficult. Night conditions make operations more difficult, but also decrease the threat's effectiveness by disrupting optical tracking.

An additional environmental problem that must be considered in weapon employment studies is jamming. It is likely that air-to-ground communications will be degraded by jamming. Radar performance will be degraded by jamming by both sides in a conflict.

The identifying feature of both CAS and CIFS is operation in proximity to friendly troops. Traditionally, this has required close communication between the ground troops and their attack aircraft. First, and most important, by good communications ground troops can ensure that their own troops are not attacked; second, they can ensure that the desired target is attacked and destroyed. A jammed environment makes this communication difficult if not impossible at times.

Tactics

Basic weapon delivery tactics are dictated by the aircraft capabilities, weapon characteristics, weather, and the threat. The weapons must be delivered within the range envelope (between a maximum and a minimum range) and in some cases must impact at a high enough grazing angle to be effective. The release conditions must be such that the aircraft can avoid weapon fragmentation. Weapon fragmentation from the first aircraft in a strike must be avoided by the second aircraft. (Timing is critical.)

The threat forces the aircraft to fly such that target acquisition is difficult and weapon delivery is not in the "optimum" part of the envelope. Jet aircraft fly as low and fast as possible. They make frequent turns to make tracking them difficult (jinking). They use terrain masking to avoid detection. This same masking keeps them from seeing the target, of course. Helicopters fly as low as possible, avoid any populated area, and also use all the masking possible.

Jet aircraft must normally increase their altitude before weapon release, entering a shallow dive or loft maneuver, or popping up and then entering a shallow dive over the target. Some weapons can also be delivered in a low-level loft (e.g., 10-degree pull-up to release) if the target can be found in time.

Helicopters conducting CIFS usually use the pop-up maneuver, search the area for the target, slew the weapon or turn the helicopter, lock on (if appropriate), track and fire. Sometimes tracking is required after weapon launch. This pop-up takes them just above the terrain- or vegetation-unmask point.

The timing of the attack pass is critical, particularly when target marking and mobile targets are involved. This coordination between the ground FAC, any airborne FAC, and the attack aircraft may also take place in a high-threat, communications-jammed environment (in the worst-case situation).

Target marking can take many forms, depending on the aircraft systems and whether the strike is at night or in the daytime. Smoke has been used for years to cue the pilot where to look for the target, or where to release the weapons if the target cannot be seen. White phosphorous (WP) smoke can be delivered from the ground or in the air (other colors are not now available).

The development of laser designators, laser spot trackers, and laser-guided bombs and missiles has provided a new capability in CAS target acquisition and attack. These laser devices provide two functions: they cue the pilot and the aircraft system to the target's location, and they provide an aim-point for the laser-guided weapon. Cueing reduces the pilot's search time, and guidance reduces the weapon's circular error probability (CEP).

TARGETING OVERVIEW

The material presented above is intended to give a flavor of some of the target acquisition aspects of close air support, without repeating much of the detail available in other reports.

CAS has a wide variety of flight profiles (medium altitude, low altitude, pop-up, etc.), weapons, and players. CAS must be conducted at night, in the daytime, and in all sorts of terrain and weather. Jets, observation aircraft (OV-10s), and helicopters engage in direct support of the ground troops (CAS and CIFS).

CAS has some of the same target acquisition problems that are found in strikes away from friendly troops (e.g., haze, masking, battlefield clutter, weather). The additional requirements to locate and communicate with friendlies near the targets, and to mark the targets, introduce additional problems. The ability to mark the targets, however, can make things easier for the attack pilot. It appears that all these requirements must be met in a medium- to high-threat environment.

TARGETING PROBLEMS

More small mobile targets will be encountered in CAS than in deep-strike attack missions. Because of their mobility, the locations of these targets will not be known exactly, and they will be "available" to attack for only a short time. Mobile targets are difficult to locate, unless marked, and they may be heavily defended.

The proximity of friendly troops brings good news and bad news. The bad news is that it is very important that the attack pilot not drop his weapons on the wrong target. His task-loading is increased by having to locate the enemy and, at the same time, know he is not threatening to friendly troops. He can't just drop his payload on, or shoot at, anything that looks man-made.

The good news is that those nearby friendly troops can mark themselves and the targets to aid the attack aircraft. The type of marking must fit the situation and be compatible with the aircraft systems.

Table 5 shows the most favorable conditions for CAS. Many of these conditions might be found in a permissive environment, against an unsophisticated enemy. However, current scenario or mission-description documents state that most of these conditions should not be expected.

TABLE 5. Optimum Conditions for CAS.

1.	Accurate aircraft navigation system (good to 100 meters)
2.	Target marking or cueing visible to pilot or avionics sensor (laser spot tracker), and accurate offset from marker to target
3.	Marking of own or friendly troops visible to aircraft
4.	Good air-to-ground communication with adequate time available for message
5.	Clearance by FAC before weapon release
6.	Positive identification of target by pilot before release
7.	Damage assessment and second-pass instructions from FAC after weapon delivery (for new aimpoint from marker)
8.	Good timing between air and ground
9.	Appropriate aircraft weapons, tactics, and target (proper warhead, fuze, impact angle, etc.)
10.	Accurate weapon release computer

Table 6 shows some of the problems that an aircrew might have in actually finding the target once all the other problems have been surmounted. These problems are caused by the target's characteristics (generally, hard to see or to locate with radar or forward-looking infrared (FLIR) sensor) and by the threat forcing the aircrew to fly low and, for jets, fast.

TABLE 6. Problems in Target Acquisition.

	Problem	Cause
1.	Small targets	Targets are mostly vehicles (tanks, APCs, ZSUs).
2.	Low-contrast targets	Targets use dirt, foliage, paint, and camouflage to avoid detection.
3.	Fleeting targets	Targets are mobile.
4.	Restricted visibility	Natural weather, battlefield smoke restrict visibility.
5.	Terrain and vegetation masking restrict visibility	Low-flight altitude of aircraft in order to avoid threat.
6.	Short search time	Threat forces high speed, single pass, or quick pop-up by aircraft.

Target marking increases the probability of the aircrew's finding the target and reduces search time to a minimum in a high-threat environment. Table 7 shows some problems with the employment of target markers. As shown in the table, there are problems with both a simple system like smoke and a complicated and expensive system like a laser designator. The laser designator also requires reliable laser tracker avionics in the aircraft.

LASER DESIGNATOR USE

A laser designator used as a marking device is precise. It is also active, and can be used (in reverse) to indicate where the forward observer is. The aircraft must be equipped with a compatible sensing system, which must be pointed in the right direction to detect the laser spot.

Use of a laser-guided weapon has one large advantage: it decreases the CEP; however, it can make other tasks in the weapon delivery process more difficult. Coordination and timing are more difficult. And the designator, whether ground or airborne, is more vulnerable than passive systems. The half-life of a designator is not very long.

An obvious need is to decrease the designation time required by our acquisition systems and by laser weapons.

TABLE 7. Target-Marker Acquisition Problems.

Problem	Cause
1. Smoke marker not always visible.	Battlefield haze, smoke. Restricted visibility. Wind blows smoke away. Not usable at night or in snow because of color.
2. Smoke marker not unique.	Enemy counters with own smoke. Colored smoke is not available, but needed.
3. Smoke marker is static.	Smoke cannot "follow" moving targets.
4. Smoke marker may not be placed accurately near target.	Inaccuracy in marker delivery, artillery firing of marker round, or communication.
5. Laser designator readiness unknown (both ground and airborne).	Operator cannot see designator spot on target.
6. Laser designator vulnerable (both ground and airborne).	Long time (10 to 30 seconds) required with spot on target (depending on tactic and weapon system).
7. Wrong laser designator and laser tracker codes sometimes used.	Poor communication makes coordination difficult.
8. Laser designators difficult to use at night.	No night sighting devices for ground laser units.
9. Target markers not visible from low-flying aircraft.	Terrain and vegetation masking.

Table 8 shows some additional targeting problems that would be encountered during night operations. The A-6E target recognition and attack multisensor (TRAM) and the F/A-18 with its FLIR would not require flares, but use of the aircraft radar system with a radar beacon, and the FLIRs will still not be easy in a high-threat environment.

TABLE 8. Night CAS Problems.

Problem	Cause
1. Aircraft must fly higher at night than in the daytime	Automatic terrain avoidance systems (if any) not totally relied on.
2. Flare illumination difficult.	Pilots do not want to overfly target to drop flares. Flare placement not accurate. No forward-firing flares in Marine Corps inventory.
3. Location of target by ground FAC difficult at night.	Night search and ranging systems are not now available.
4. Target acquisition (search) by airborne sensor alone is not likely.	Restricted field of view, aircraft and target location uncertainty, low flight altitude, time limitation.
5. Use of a ground beacon alone is not good enough for target strike.	Range and azimuth from beacon to target can be inaccurate.
6. Location of identification point (IP) at night for pop-up attack is difficult.	IPs are usually visual fixes. Most current aircraft do not have a good enough navigation system.

ASSOCIATED PROBLEMS AND SOLUTIONS

It is unrealistic to consider the target acquisition function as an independent item in the CAS process. Related processes and problems that might be considered to be outside, or on the fringes, of targeting are shown in Table 9. These factors certainly affect the ability of the aircrew to find the target.

TABLE 9. Communication and Coordination Problems.

Problem	Cause
1. Unrestricted air-to-ground communication probably not possible.	Enemy jamming. Low-level flight makes communications difficult.
2. Description of target location takes a long time, if possible at all.	Different views of target area from air and ground. Description not precise.
3. Split-second timing difficult (precise time-on-target).	Poor aircraft clocks and navigation systems. Enemy diversions, bad weather.
4. Timely target designation for weapon delivery difficult.	Mobile targets have a short exposure time. A multiple-aircraft strike complicates coordination and communication.

Figure 1 is a block diagram of the interrelated factors for a fixed set of conditions that an operational group would face in wartime. The only feedback loop shown goes from "effectiveness" to "tactics." In a given campaign, the military forces must operate against a specific threat and target, with the aircraft, avionics, and the marking devices available in the inventory. The only factor they can change is tactics if they are not satisfied with their effectiveness. Some recent tactics changes have had good success in countering threats and communications jamming.

Figure 1 also illustrates the "associated" solutions to the targeting problem. If aircraft avionics are changed to improve survivability (e.g., improved chaff), the tactics could be changed to improve target acquisition capability (e.g., fly higher). If a target-marking device on the ground is changed to improve target acquisition capability and thereby improve effectiveness, aircraft avionics could remain the same. And so on.

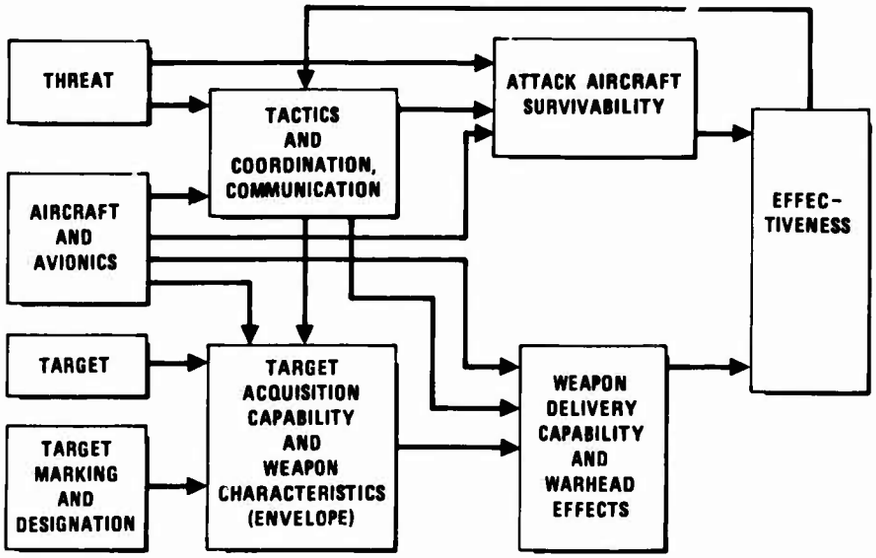

FIGURE 1. CAS Factors for Fixed Set of Equipment and Environmental Conditions.

TARGETING IMPROVEMENT GUIDELINES

A good targeting development strategy would include the following:

1. The targeting must be successful under flight conditions that are necessary to deal with the threat (e.g., low altitude, high speed).

2. The targeting performance should be compatible with the delivery envelopes of the available weapons (e.g., a minimum range of 6,000 feet).

3. Operation of the targeting system must not increase the aircrew work load since it is already too high.

Information reviewed during this study indicates that the threats will remain high and probably increase in intensity. Today's less-developed cultures will soon have sophisticated antiair weaponry, so the "low-threat" environment may be a thing of the past.

One approach is to integrate targeting, electronic countermeasures, and weapon developments that would attack the target and threat (sometimes the same) as a system. If the threats can be detected, located, and killed or suppressed, attacking other targets becomes much easier. And until the threats can be suppressed, CAS may well be an unacceptable mission, because of unacceptable attrition rates.

PRELIMINARY RECOMMENDATIONS

What would be the most important improvements in USMC Air CAS ability, from the targeting standpoint? The following seem to predominate in all of the above descriptions:

1. Improved threat acquisition and suppression

2. Improved communication in the jammed environment

3. Improved target marking

4. Improved friendly marking

5. Improved target acquisition, per se.

6. Decreased aircraft and target designator exposure time

What proposed "improvements" may not help much? A listing should include:

1. Proposals for improving or modifying current, often expensive, products without clearly showing what the improvement will buy.

2. Longer-range weapons that do not deal with the associated severe long-range target acquisition problem (especially over land).

3. Concepts that do not deal with the threat and cannot be used at very low altitudes or at high speeds (for jets).

4. Concepts that purport to increase the target acquisition range (e.g., through better resolution), but do not solve the masking-from-low-altitude or very-short-exposure-time problems.

5. Concepts that increase aircrew decision-making and work load.

6. Concepts that are not compatible with our current and near-future weapons and their envelopes.

SUMMARY

This paper has briefly described CAS operations and identified some of the target acquisition problems. Discussion of associated problems such as communications has also been included. Some general recommendations have been made on areas needing immediate attention, and a strategy for longer-range development has been suggested.

The information contained in this study is intended to be used in combination with a technology survey to produce specific hardware development proposals.